Worksheet: The Atom, Protons, Neutrons, Electrons

| Substance | Mass(A) | At. No.(Z) | Protons | Neutrons | Electrons | Charge |
|---|---|---|---|---|---|---|
| 1. $^{27}_{13}Al$ | | | | | | |
| 2. | 16 | 8 | | | 8 | 0 |
| 3. $^{24}Mg$ | | | | | | |
| 4. $^{39}_{19}K^{+1}$ | | | | | | |
| 5. | 23 | | 11 | | 10 | |
| 6. | 31 | 15 | | | | -3 |
| 7. $^{28}_{14}Si^{+4}$ | | | | | | |
| 8. $^{33}_{16}S$ | | | | | | |
| 9. $^{19}_{9}F$ | | | | | | |
| 10. | 40 | 20 | | | 18 | |
| 11. protium | | | | | | |

12. $^{35}_{17}X$ What element is X?

13. What element has 3 e-'s?

14. $^{140}_{58}Ce^{+2}$ has how many elecetrons?

15. $^{190}_{76}X$ What element is X?

Worksheet: Isotopes

1. Calculate the atomic mass of oxygen. The naturally occurring element consists of 99.759% O-16, atomic mass 15.99491u; 0.037% O-17, atomic mass 16.99914u; and 0.204% O-18, atomic mass 17.99916u.

2. Element, Tadmium, was found in another galaxy. Four isotopes were found. $^{11}Tm$ (11.00u), $^{10}Tm$ (10.00u), $^{12}Tm$ (12.00u), and $^{15}Tm$ (15.00u). The relative abundances were 25.36% $^{11}Tm$, 12.56% $^{10}Tm$, 40.35% $^{12}Tm$, and then they ran out of material.

a) What % was the isotope $^{15}Tm$?

b). What would be the atomic mass of Tadmium?

3. Naturally occurring boron consists of $^{10}B$ (10.013u) and $^{11}B$ (11.009u). The atomic mass of boron is 10.811u. What is the relative abundance of **each** of the two isotopes?

25

## Sample Problem 8

In naturally occurring samples of the element boron, there are two kinds of isotopes, boron-10 and boron-11. The relative abundances of these isotopes in naturally occurring samples and their masses are given below. From this information, calculate the atomic mass of boron. 10.81

| Isotope | Relative abundance | Atomic mass of the isotope |
|---|---|---|
| boron-10 | 19.78% | 10.013 u |
| boron-11 | 80.22% | 11.009 u |

## Practice Problem

Section 6-21

58. Calculate the atomic mass of potassium if the abundance and atomic masses of the isotopes making up its naturally occurring samples are as given below. (39.1)

| Isotope | Relative Abundance | Atomic Mass |
|---|---|---|
| potassium-39 | 93.12% | 38.964 |
| potassium-41 | 6.88% | 40.962 |

37. Calculate the atomic mass of magnesium based on the information provided below. *6-21*
24.31

**Relative Abundance of Magnesium Isotopes**

| Isotope | Relative abundance | Atomic mass |
|---|---|---|
| magnesium-24 | 78.70% | 23.985 |
| magnesium-25 | 10.13% | 24.986 |
| magnesium-26 | 11.17% | 25.983 |

70. The atomic mass of copper is 63.540 u. It is composed of two isotopes, Cu-63 and Cu-65, with atomic masses of 62.930 u and 64.928 u, respectively. What is the relative abundance (%) of these isotopes in naturally occurring samples of copper? 69.47% Cu-63, 30.53% Cu-65

Gift Wrapped Lab

I. Title: Gift Wrapped Lab(1 pt)

Intro: The foundation of chemistry lies in determinig the properties of matter. What is an atom? A proton? An electron? This is fundamentally an exercise in figuring out how to deduce information about what we cannot see, like individual atoms, from things which we can see(or hear, feel, or measure). In science, we call this "Model Building." Your job in this lab is to develop and test and redevelop and re-test a series of models until you think you have arrived at the "correct" model. Basically, you are retracing some of the steps that Rutherford went through to develop his model of the atom.

II. Purpose- You come up with this in your own words(2 pts)

III. Procedure: Using any method which you think is effective, gather data about the shape of the interior of the boxes provided. YOU MAY NOT OPEN THE BOXES!!!
Write a step by step procedure of how you went about collecting your data to determine the interior of the boxes.(3 pts)

IV. Data
a. Write out a list of "observations" which you gathered during your investigation and a corresponding list of "inferences" which you made from your data.Make two columns. Be prepared to defend both your observations and inferences. You must have a minimum of 6 observations and inferences to get the maximum points. (6 pts)

b. Sketch what you think the interior of each of the gift wrapped boxes look like to scale on the attached data sheet. (12 pts=2 pts per box)

V. Analysis Questions
1. Did you change your "model" after discussion with your lab partner and other lab groups? What convinced you to change or not change? (2 pts)

2. What kinds of things could you have used to improve your modeling of the box's interior? List some modern machines or technologies which could have aided you, and explain why they would have improved your results. (2 pts)

3. What ideas did you have as a child that you later found out were incorrect or untrue? Did you change those ideas or did someone else help/convince you to change your ideas? Were those incorrect ideas useful to you as a child even though they were incorrect? Do not use Santa Clause!! (2 pts)

4. Have there ever been any models developed by scientists which were incorrect? Using your experience from this lab, explain why scientists might develop models which do not always turn out to be true? Note: you may not use Rutherford as your example. (2 pts)

VI. Conclusion: Narrative- A new format for this lab.(8 pts)
Write a discussion about the lab which addressed the journey you took to get to your "model" (2 pts). What did you learn? (2 pts). What was the most interesting part of this lab? (2 pts). What parts were misleading in this lab? (2 pts).

Gift Box Experiment

Shade all of the areas which you believe are inaccessible to the marble located inside the box. If there is a barrier in the box, draw in its shape.

SAMPLE BOX #1

SAMPLE BOX #2

BOX #1

BOX #2

BOX #3

BOX #4

BOX #5

BOX #6

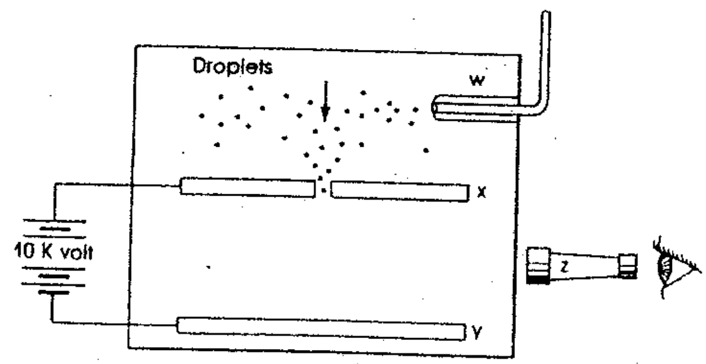
Name ____________________

Class ____________ Date ____________

# Composition of the Atom

## A. Millikan Oil-Drop Experiment

In 1909, the American physicist Robert Millikan measured the charge of an electron. Using the apparatus illustrated below, he introduced a fine mist of oil into a closed chamber. The droplets of oil passed between two electrically charged plates through which he was able to influence their rates of descent. Observing the individual droplets through a microscope, Millikan was able to adjust the electrical force so that the drops moved away from whichever plate had the same charge. He timed the drops' rate of movement. From this information, he was able both to determine the charge of an electron and to suggest a value for its mass. Study the diagram below and answer the following questions. Write the letter of each answer in the space provided on the left.




____ 1. To cause a negatively charged oil droplet to move upward: plate Y should have ______.
- a. a positive charge
- b. a negative charge
- c. an excess of protons
- d. an excess of neutrons

____ 2. The purpose of device Z is to ________.
- a. observe the electrical potential difference (voltage) between the plates
- b. separate spectral emissions
- c. magnify droplets of liquid
- d. locate positively charged particles

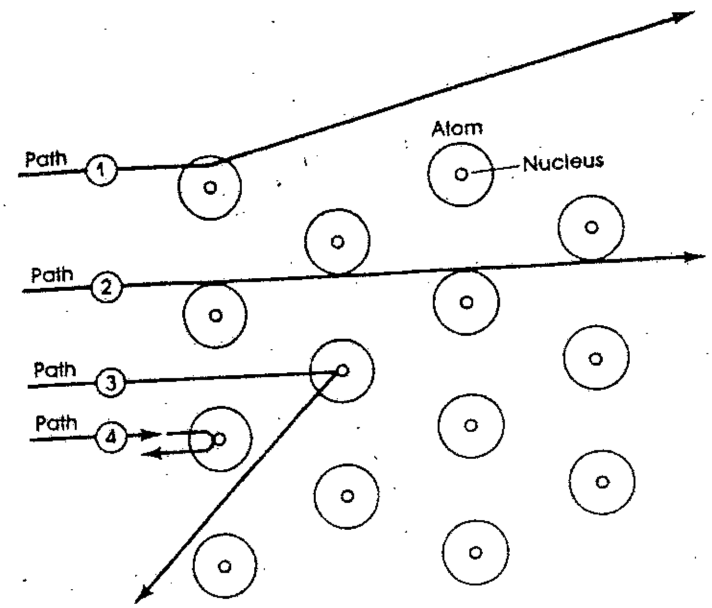
____ 3. If a droplet was momentarily suspended between the electric plates, ________.
- a. the number of protons in the droplet equaled the number of electrons
- b. there was no charge on the plates
- c. the droplet weight was exactly balanced by forces of electrical repulsion/attraction
- d. the mass of the electrons in the droplet equaled the mass of the protons

____ 4. The function of device W is to ________.
- a. remove excess mist
- b. supply protons
- c. monitor relative humidity
- d. produce a mist from liquid oil

____ 5. If the electrical leads to plates X and Y were reversed, negatively charged oil droplets that had been moving upward would ________.
- a. remain suspended
- b. move downward to plate Y
- c. move upward to plate X
- d. acquire a positive charge

## B. The Rutherford Experiment

Our modern view of atomic structure is based to a large extent on the work that British scientists Rutherford and Geiger did in 1911. In the classic experiment, positive alpha particles bombarded a sheet of gold foil. The paths followed by those particles are illustrated in the following figure. Study the diagram and answer the questions below.




____ 1. Which of the four paths was most common?
a. 1 b. 2 c. 3 d. 4

____ 2. Which of the four paths was least common?
a. 1 b. 2 c. 3 d. 4

____ 3. Path 2 was a straight line because of the alpha particles' ________.
a. magnetic repulsion
b. high velocity
c. distance from gold nuclei
d. interaction with electrons

____ 4. Path 4 will most likely ________.
a. never be observable
b. be characteristic of only the fastest-moving alpha particles
c. be characteristic of alpha particles that move directly toward a nucleus
d. result in an atomic reaction

____ 5. When Rutherford analyzed his results, he suggested that ________.
a. the atom was mostly empty space
b. atoms contained a small, dense center
c. the atomic center was positive in charge
d. all of the above were true

## C. Atomic Theorists

The modern concept of atomic structure is based upon the work and ideas of numerous scientists. Match each of the statements below with the name of the scientist most closely associated with the achievement described. Fill in each blank with the correct name.

| | | | | |
|---|---|---|---|---|
| Becquerel | Crookes | Dalton | Joliot-Curie | Rutherford |
| Chadwick | Curie | Geiger | Millikan | J.J. Thomson |

1. proposed first atomic model that accounted for the electrical nature of the atom ______________________
2. measured the charge of an electron ______________________
3. suggested that alpha particles may rebound at an angle approaching 180° after coming close to a nucleus ______________________
4. proposed that an atom was a sphere that was equally dense throughout ______________________
5. discovered a neutral beam that had high penetrating power ______________________
6. used metallic foil as a target for alpha bombardment ______________________
7. developed the cathode-ray tube (CRT) ______________________
8. is credited with the discovery of radioactivity ______________________
9. discovered the radioactive element polonium ______________________
10. was first to identify the neutron ______________________

## D. Nuclear Symbols

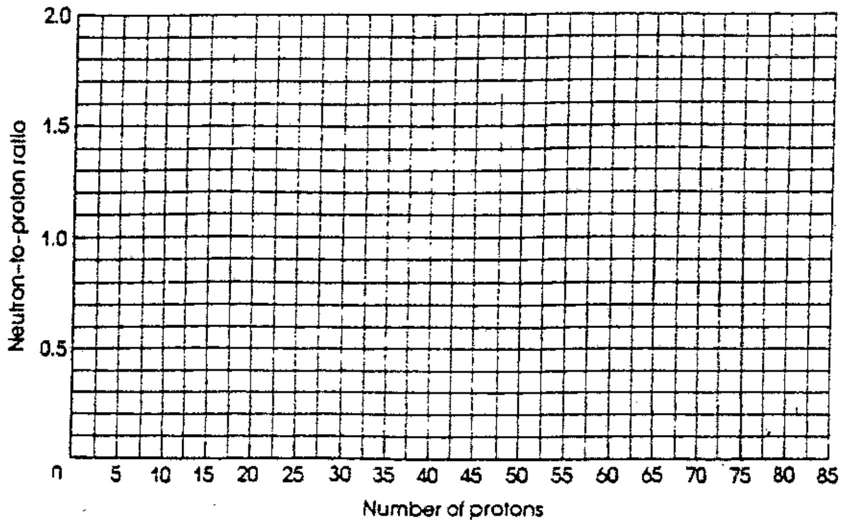
Atomic symbols are often accompanied by notation that gives information on atomic composition. The subscript, written to the lower left of an atomic symbol, represents the atomic number. The superscript, written to the upper left of the symbol, represents the mass number, or total number of protons and neutrons. Using this information, complete the following table. Assume that the atomic mass of one neutron or one proton equals 1 amu.

| SYMBOL | ATOMIC NUMBER | ATOMIC MASS (amu) | NUMBER OF PROTONS | NUMBER OF NEUTRONS | NUMBER OF ELECTRONS |
|---|---|---|---|---|---|
| $^{12}_{6}C$ | | | | | |
| $^{40}_{18}Ar$ | | | | | |
| $^{127}_{53}I$ | | | | | |
| $^{23}_{11}Na$ | | | | | |
| $^{20}_{10}Ne$ | | | | | |
| $^{48}_{22}Ti$ | | | | | |
| $^{40}_{20}Ca$ | | | | | |
| $^{238}_{92}U$ | | | | | |

## E. Nuclear Stability

The stability of a nucleus is dependent upon the ratio of its component particles. In the stable isotopes of lighter nuclei, the ratio of neutrons to protons approximates a value of one. The ratio in the stable isotopes of heavier nuclei approaches a value of 1.5. Ratios falling outside this "belt" of stability correspond to radioactive, or unstable nuclei.

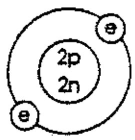
Complete the following table of representative stable nuclei. Determine the neutron-to-proton ratio of each by dividing the number of neutrons by the number of protons. Plot the resulting points on the grid provided on the next page.




| ISOTOPE | NUMBER OF NEUTRONS | NUMBER OF PROTONS | NEUTRON-TO-PROTON RATIO |
|---|---|---|---|
| $^{4}_{2}He$ | | | |
| $^{9}_{4}Be$ | | | |
| $^{12}_{6}C$ | | | |
| $^{16}_{8}O$ | | | |
| $^{20}_{10}Ne$ | | | |
| $^{27}_{13}Al$ | | | |
| $^{37}_{17}Cl$ | | | |
| $^{40}_{20}Ca$ | | | |
| $^{56}_{26}Fe$ | | | |
| $^{58}_{28}Ni$ | | | |
| $^{64}_{30}Zn$ | | | |
| $^{79}_{35}Br$ | | | |
| $^{90}_{40}Zr$ | | | |
| $^{98}_{42}Mo$ | | | |
| $^{107}_{47}Ag$ | | | |
| $^{127}_{53}I$ | | | |
| $^{138}_{56}Ba$ | | | |
| $^{142}_{60}Nd$ | | | |
| $^{158}_{65}Tb$ | | | |
| $^{174}_{70}Yb$ | | | |
| $^{184}_{74}W$ | | | |

## F. Hydrogen Isotopes

Atoms are made up of subatomic particles, such as protons, neutrons, and electrons. The nuclei of atoms that make up isotopes of an element differ. There are three known isotopes of the element hydrogen. Make a drawing representing each of these isotopes. (A drawing of a helium isotope is shown below as an example.)




Helium, $^{4}_{2}He$ Protium, $^{1}_{1}H$ Deuterium, $^{2}_{1}H$ Tritium, $^{3}_{1}H$

1. Explain why the atomic mass of hydrogen is 1.0079 and not a whole number.

_______________________________________________

_______________________________________________

2. Do the numbers of electrons for neutral isotopes of the same element differ? ___________

3. Do the numbers of protons for such isotopes differ? ___________

4. Do the numbers of neutrons for such isotopes differ? ___________

5. Do the atomic numbers of such isotopes differ? Explain.

_______________________________________________

_______________________________________________

6. Do the mass numbers of such isotopes differ? Explain.

_______________________________________________

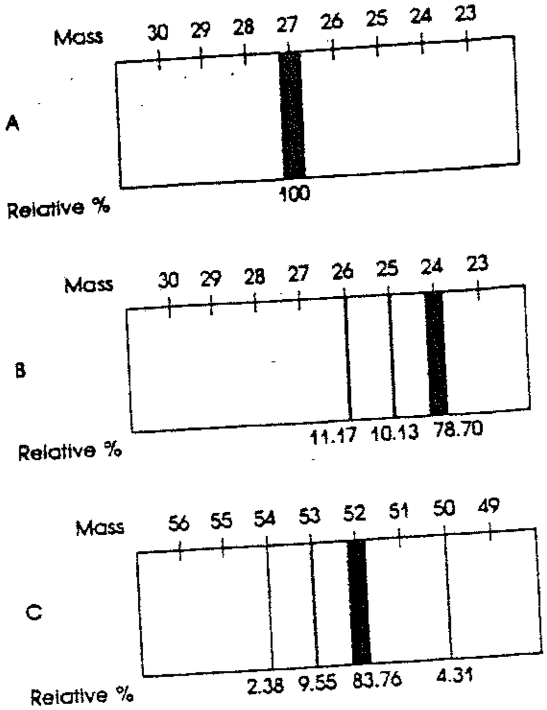
_______________________________________________

_______________________________________________



## G. Analyzing a Spectrograph

A mass spectrograph (or a mass spectrometer) is an instrument used to separate an element's isotopes and to measure their relative abundances. Within this device, beams of an element's ions are passed through a strong magnetic field. As they are passed through, they respond to the magnetic force. Ions of greater mass possess more inertia, or more of a tendency to continue to move in a straight line, and so deviate only slightly from their projected path. Ions of lesser mass are more greatly influenced by the field and demonstrate greater deviation. Examine the three mass spectrograph readings illustrated on the next page and answer the questions that follow. Note that the upper scale of each spectrograph shows atomic mass (in amu). Below each spectrograph, the percents of the various isotopes present are given.




1. a. What is the atomic mass of the isotope of the element represented by spectrum A? __________

   b. What are the name and atomic symbol of element A? (Consult a periodic table or table of atomic masses.) __________

2. a. What are the atomic masses of the isotopes in spectrum B? __________

   b. Based on the experimentally obtained values of atomic mass and percent, calculate the average atomic mass of this element. Show your work.

   __________

   c. What are the name and symbol of this element? __________

   d. What are the symbols, including superscripts and subscripts, of the isotopes of this element? __________

   e. Which isotope deviated most from its straight-line path? __________

3. a. What are the atomic masses of the isotopes in spectrum C? __________

   b. Calculate the average atomic mass of this element.

   __________

   c. What are the name and symbol of this element? __________

   d. What are the symbols, including superscripts and subscripts, of the isotopes of this element? __________

   e. Which isotope deviated most from its straight-line path? __________

# H. Composition-of-the-Atom Word Scramble

Use the clues provided to help you unscramble the letters to form words related to the information in Chapter 8. The letters in the circles spell out, in order, the name of a famous chemist.

**CLUES**

1. Pieces of inert metal connected to a power source
2. Element discovered by Marie Curie
3. Atoms with the same atomic number but different mass numbers
4. Radiation emanation consisting of high-speed helium nuclei
5. Center of the atom
6. Subatomic particle with no charge
7. Element with atomic mass of 19.0
8. A mass ____________, a device used to determine atomic masses
9. A positively charged particle
10. Element with atomic number of 1

1. T E R D L C E E O  _ _ _ _ _ ○ _ _ _
2. L O M U O P N I  _ _ _ _ _ _ ○ _
3. S O O S T I P E  _ _ _ ○ _ _ _ _
4. H A A L P  _ _ _ ○ _
5. S U C U N E L  _ _ _ _ ○ _ _
6. N E T N O U R  _ _ _ _ ○ _ _
7. N E O L I R F U  ○ _ _ _ _ _ _ _
8. E P R T G S C H P O R A  _ _ _ _ _ _ ○ _ _ _ _ _
9. T O R N O P  _ ○ _ _ _ _
10. O G Y D N E H R  _ _ ○ _ _ _ _ _

Name: ____________________

# WORKSHEET II: Electron Configurations and Notations

| Symbol | Atomic Number | Electrons in Energy Levels K | L | M | N | O | Electron-configuration Notation |
|---|---|---|---|---|---|---|---|
| H | 1 | | | | | | |
| He | 2 | | | | | | |
| Li | 3 | | | | | | |
| Be | 4 | | | | | | |
| B | 5 | | | | | | |
| C | 6 | | | | | | |
| N | 7 | | | | | | |
| O | 8 | | | | | | |
| F | 9 | | | | | | |
| Ne | 10 | | | | | | |
| Na | 11 | | | | | | |
| Mg | 12 | | | | | | |
| Al | 13 | | | | | | |
| Si | 14 | | | | | | |
| P | 15 | | | | | | |
| S | 16 | | | | | | |
| Cl | 17 | | | | | | |
| Ar | 18 | | | | | | |
| K | 19 | | | | | | |
| Ca | 20 | | | | | | |
| Sc | 21 | | | | | | |
| Ti | 22 | | | | | | |
| V | 23 | | | | | | |
| Cr | 24 | | | | | | |
| Mn | 25 | | | | | | |
| Fe | 26 | | | | | | |
| Co | 27 | | | | | | |
| Ni | 28 | | | | | | |
| Cu | 29 | | | | | | |
| Zn | 30 | | | | | | |
| Ga | 31 | | | | | | |

## WORKSHEET II: (Cont'd) Electron Configurations and Notations

| Symbol | Atomic Number | Orbital Notation<br>1s 2s 2p (x y z) 3s 3p 3d 4s 4p | Electron-dot Notation |
|---|---|---|---|
| H | 1 | | |
| He | 2 | | |
| Li | 3 | | |
| Be | 4 | | |
| B | 5 | | |
| C | 6 | | |
| N | 7 | | |
| O | 8 | | |
| F | 9 | | |
| Ne | 10 | | |
| Na | 11 | | |
| Mg | 12 | | |
| Al | 13 | | |
| Si | 14 | | |
| P | 15 | | |
| S | 16 | | |
| Cl | 17 | | |
| Ar | 18 | | |
| K | 19 | | |
| Ca | 20 | | |
| Sc | 21 | | |
| Ti | 22 | | |
| V | 23 | | |
| Cr | 24 | | |
| Mn | 25 | | |
| Fe | 26 | | |
| Co | 27 | | |
| Ni | 28 | | |
| Cu | 29 | | |
| Zn | 30 | | |
| Ga | 31 | | |

# FLAME TESTS 13

When elements are heated to high temperatures, they may be placed in an excited state. In an excited state, the electrons move to higher energy levels. The changes in energy that occur when the excited atoms return to their ground state cause the substance to be luminous or emit light. The observed colors or spectrum of the substance is caused by the set of visible wavelengths of light emitted. Since each element emits a unique set of wavelengths, emission spectra can be used as a tool to identify the elements.

One method used to demonstrate the emission spectrum of a substance is the flame test. Using this method, a small amount of a substance is heated and the characteristic glow of the substance is observed. In this experiment you will perform a flame test on several metallic salts. Based on your observations, you will develop a reference table which lists the flame color for each metal ion. You will then perform a flame test on an unknown substance. By comparing your observations to the data in your reference table, you will be able to identify the metal ion in the unknown substance. Finally, you will use cobalt glass as a tool for identifying the components of a metallic salt mixture.

### Objectives

In this experiment, you will

- observe the spectra emitted from selected ions;
- identify metallic ions by the color emitted during vaporization of the element; and,
- evaluate the usefulness of this method of metal identification.

## EQUIPMENT

platinum wire loop
beaker (any size)
laboratory burner
2 cobalt glass squares

## PROCEDURE

1. Prepare a table for recording your results as directed in the Analysis.
2. Clean a platinum wire or loop by dipping it in concentrated hydrochloric acid, HCl, and then heating it in the edge of the laboratory burner flame (nonluminous portion). CAUTION: *HCl causes burns, avoid skin contact.* Repeat the dipping and heating until no color is imparted from the wire.
3. Dip the clean wire or loop in a moistened sample of sodium nitrate, $NaNO_3$, and heat as shown in Figure 13-1. Observe the color and record in your table.
4. Repeat Steps 2 and 3 (be sure the wire is clean before testing another metal) for compounds of barium, copper, calcium, potassium, strontium, and lithium. Observe and record the color for each in your table.
5. Obtain a sample of unknown from your teacher. Repeat steps 2 and 3.
6. Obtain a mixture of sodium and potassium compounds. With a clean loop observe the

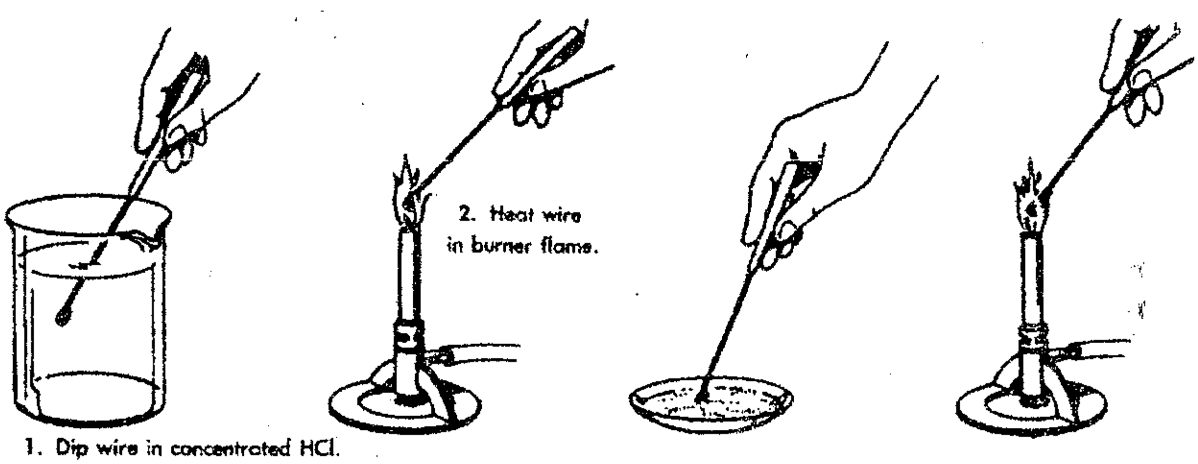



FIGURE 13-1. Procedure for flame test.

color. Repeat the exercise but observe the color through two pieces of cobalt glass. Record the results. Use the cobalt glass and observe sodium and potassium ions separately. Record the results in your table.

## ANALYSIS

Develop a table for your observations. Use Table 13-1 as a guide.

Table 13-1

| Metal Ion | Flame Color |
|---|---|
| Sodium, $Na^{+}$ | |
| Barium, $Ba^{2+}$ | |
| Calcium, $Ca^{2+}$ | |
| Copper, $Cu^{2+}$ | |
| Potassium, $K^{+}$ | |
| Strontium, $Sr^{2+}$ | |
| Lithium, $Li^{+}$ | |
| *Unknown* | |
| Sodium & Potassium, $Na^{+} + K^{+}$ | |
| | **Flame Color with Cobalt Glass** |
| Sodium & Potassium, $Na^{+} + K^{+}$ | |
| Sodium, $Na^{+}$ | |
| Potassium, $K^{+}$ | |

## CONCLUSIONS

1. What metal ion would you predict to be contained in the sample of unknown? Why?
2. Based on your results and observations would this method be practical to determine metals in a mixture? If not, why not?
3. Explain the reason potassium was visible when using the cobalt glass.
4. Explain the effect of the nitrate ion in solution on the color emission.
5. Give at least two reasons why the flame test is sometimes invalid.
6. Describe the common characteristics of flame tests that would be observed if a spectroscope were used.
7. What other means of qualitative analysis are used to identify metals?

## FURTHER INVESTIGATIONS

1. Explain the difference between emission and absorption spectra.
2. Advertising lights are produced by sealed tubes of various excited noble gases which emit colored light. Using references, explain the techniques used in producing the lights.
3. Use reference sources and determine the flame color for five additional metal ions.

# Spectroscope Lab
Part 1

## Introduction

**A spectroscope contains a diffraction grating that separates electromagnetic radiation into it: component wavelengths. The spectroscope can be used to measure <u>absorption</u> or <u>emission</u> spectra.**

All spectral instruments do basically one thing. They break light (electromagnetic radiation) into its constituent components. In the visible, white light will be dispersed into the colors Red. Orange, Yellow, Green. Blue and Violet. In Part 1 of this lab we will be using a spectroscope: however, we will be also using a spectrophotometer in Part 2 of this lab. What is the difference between the terms spectroscope, spectrometer, or spectrophotometer? Rather the differing suffixes refer to the method of detection: -scope for visual use; -meter implies photography: and -photomete uses some electronic means.

All gases when heated to high temperatures will give off light at particular wavelengths characteristic to the number of electrons in the atomic orbits of the material. Every element, as wel ion or molecule, has its own 'finger-print'. Therefore when the light from the sun and stars are observed, elements in the atmospheres of stars are detectable as characteristic wavelengths (colc which enable the astronomer to identify that material, as well as the temperature at which it exists. and a host of other physical characteristics. The device used to separate the varying wavelengths detect these chemical and physical properties is known as a spectral instrument. The science of doing so is spectroscopy.

When light other than a white light is passed through a prism a series of lines appear other than a continuous spectrum. These lines of color are called bright line spectra. These lines can b produced by either flame tests or spectroscope. Different elements give it own unique set of spec lines. These spectral lines are the fingerprints of elements. If many atoms in a sample of an elem are excited by radiation sources, they give off various frequencies of radiation as their electrons d back to their ground state energy levels. This is often referred to as fluorescence. It is the emitta of visible light from a substance under stimulation of radiation. Some of this radiation may be visit as the characteristic bright line spectrum of the element.

Each line in the spectrum represents a particular "quantum jump" that an electron can mak that atom. Each line also represents radiation of a definite wavelength an frequency. The energy a quantum of radiation of that frequency also can be calculated. This quantum is the energy lost an electron as it changes levels in the atom.

## Objective

In this experiment, you will identify the bright line spectra as the fingerprints of the certain elements. You will explore atoms in a sample that are excited at the same as they give off variou frequencies of radiation. When their electrons drop back to their ground state energy levels, the emit light.

## Procedure

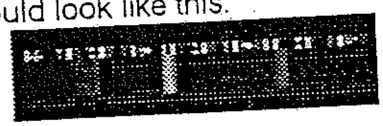
Select 4 spectral tubes to evaluate

1. Place the spectral stand on a sturdy and stable surface near an outlet.
2. Hook one metal end of a gas tube to the upper gripper by squeezing.
3. Move the upper gripper up or down to line up the gas tube with the lower gripper.
4. Once lined up squeeze the lower gripper so it connects with the metal part of the gas tube.
5. Once the gas tube is in place. Plug the lamp in and turn the light on.

**Using the Spectroscope**

When using a spectroscope, eliminate as much external light as possible so that the only light entering the instrument is due to the light sourcebeing examined. If the source is a gas emission tube DO NOT TOUCH it! Gas emission tubes operate at high voltages and will cause electric shocks if touched.

6. Take the spectroscope and hold it up to your eye. (Don't directly touch the spectroscope to your eye)
7. Hold the smaller part up to your eye and look into the light. Line the left slit up with the light and read the spectral lines. They should look like this.



Draw the lines below.

Helium

4 | 5 | 6 | 7

Hydrogen

4 | 5 | 6 | 7

Neon

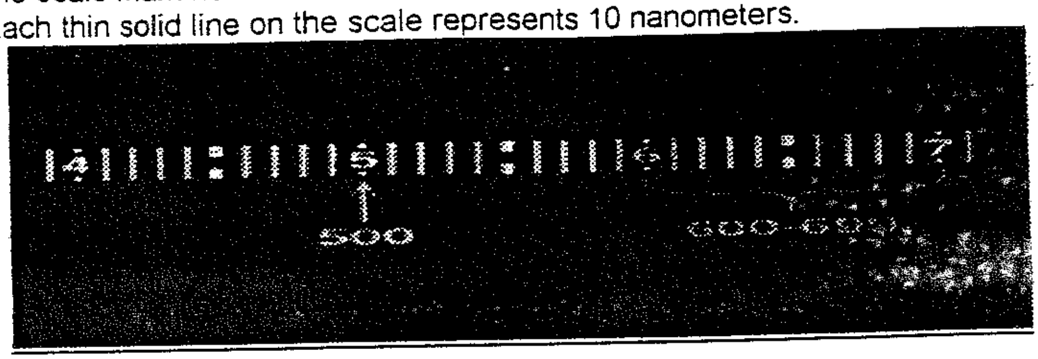
4 | 5 | 6 | 7

Krypton

4 | 5 | 6 | 7

## Taking readings

The spectrum is displayed on a wavelength scale inside the spectroscope, to the right of the slit. The numbers on the scale mark hundreds of nanometers, and the thick dashed lines are 50 nanometer increments. Each thin solid line on the scale represents 10 nanometers.




## Question

The student using the spectroscope on the left sees a red line at 615 nm, while the student using the spectroscope on the right sees the red line at 630 nm. Explain this discrepancy. Who obtained a more correct reading?

**Answer**

The students are examining the tube from different angles, so they will see slightly different wavelengths. To see more similar wavelengths, they should position their spectroscopes at approximately the same distance and angle from the emission tube.

When measuring a spectrum, the spectroscope slit should be aligned with the tube, so the student on the left obtained a more correct reading.

## Conclusion questions

1. Explain why things fluoresce?

2. What is meant by the statement " Spectral lines are fingerprints of elements".

3. What do you called the band of light that is produced when white light is passed through a prism?

4. What do you called the band of light that is produced when fluoresced light is passed through a prism?

# Worksheet: Electron Arrangement

| Long Method | Energy Level Notation | Energy Level Diagram | Electron Configuration | Orbital Notation | Electron Dot |
|---|---|---|---|---|---|
| 1. Neon | | | | | |
| 2. Phosphorous | | | | | |
| 3. 28 e's | | | | | |
| 4. 11 e's | | | | | |
| **Short Method Noble Gas Core** | | | | | |
| 5. Astatine | | | | | |
| 6. Tin | | | | | |
| 7. 66 e's | | | | | |
| 8. 91 e's | | | | | |

# Worksheet: E lectron Arrangement

| Long Method | Energy Level Notation | Energy Level Diagram | Electron Configuration | Orbital Notation | Electron Dot |
|---|---|---|---|---|---|
| 1. Boron | | | | | |
| 2. Gallium | | | | | |
| 3. 12 e's | | | | | |
| 4. 9 e's | | | | | |
| Short Method<br>Noble Gas Core | | | | | |
| 5. Zirconium | | | | | |
| 6. Gold | | | | | |
| 7. 95 e's | | | | | |
| 8. 63 e's | | | | | |

# Quantum numbers # 1

1. State the four quantum numbers and the possible values they may have.

2. Name the orbitals described by the following quantum numbers

   a. n = 3, L = 0
   b. n = 3, L = 1
   c. n = 3, L = 2
   d. n = 5, L = 0

3. Give the n and L values for the following orbitals

   a. 1s
   b. 3s
   c. 2p
   d. 4d
   e. 5f

4. Place the following orbitals in order of increasing energy:

   1s, 3s, 4s, 6s, 3d, 4f, 3p, 7s, 5d, 5p

5. What and the possible $m_L$ values for the following types of orbitals?

   a. s
   b. p
   c. d
   d. f

# Quantum numbers # 1

6. How many possible orbitals are there for n =

   a. 4
   b. 10

7. How many electrons can inhabit all of the n=4 orbitals?

8. Tabulate all of the possible orbitals (by name, i.e. 4s) for n=4 and give the three quantum numbers which define each orbital.

9. Write electron configurations for the following atoms:

   a. H
   b. Li
   c. N
   d. F
   e. Br

Quantum Numbers

Find the maximum number of electrons that fit the following criteria:

1. n=0, l=0, m=0

2. n=2, l=1, m=-1, s= -1/2

3. n=3

4. n=2, l=2

5. n=1, l=0, m=0

6. n=2, l=1

7. n=3, l=2

8. n=5, s= +1/2

Worksheet: Electron Arrangement

| Element | Electron Configuration (Long and Short) | Orbital Notation (Long and Short) |
| --- | --- | --- |
| 1. Bromine | | |
| 2. Xenon | | |
| 3. Cerium | | |
| 4. Tungsten | | |
| 5. Osmium | | |
| 6. U | | |
| 7. He | | |
| 8. Ca | | |
| 9. Cd | | |
| 10. Cf | | |
| 11. Hg | | |
| 12. 19 e's | | |
| 13. 47 e's | | |
| 14. 16 e's | | |
| 15. 3 e's | | |